DESIGN AND TESTING OF MULTIPOLE MAGNETS FOR THE DARESBURY SYNCHROTRON RADIATION SOURCE

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Abstract. The multipole magnets for the Synchrotron Radiation Source at Daresbury Laboratory are of a novel design and allow the generation of many different field harmonics in a single magnet. In addition to providing a powerful sextupole field for chromaticity correction other fields ranging from dipole to decapole can be produced in both normal and skew orientations. The redesign of the magnet following experience gained with a prototype is described and the results of magnetic measurements on 18 production magnets are presented. Some details of the method of computer control of the windings are also given.

INTRODUCTION

The 2 GeV electron storage ring of the Daresbury Synchrotron Radiation Source is presently being commissioned and will soon become operational[1]. In addition to the main magnet systems for injecting the electron beam and those for bending and focusing[2] a number of different types of correction field are also required distributed around the ring. Horizontal and vertical dipole fields and skew-quadrupole fields are required to control the position and shape of the electron beam and so directly affect the characteristics of the source of synchrotron radiation as seen by a user of the facility. Higher order sextupole, octupole and decapole fields are needed to counteract various beam instabilities and resonances. In particular relatively strong sextupole fields are required to control the chromaticity of the beam in order to combat an instability known as the "head-tail" effect.

In the SRS storage ring the amount of straight section space available for correction magnets is limited and so from an early stage in the design it was proposed to combine all of the required correction functions in a single novel type of magnet[3]. The resulting magnet allows fields ranging from dipole to decapole in both normal and skew orientations to be set up under computer control but unlike multipole magnets developed at other laboratories[4,5] this device has the unique feature of incorporating a separately controllable powerful sextupole field which is produced by an additional set of coils.

In 1976 a prototype was constructed and its successful operation demonstrated the feasibility of the magnet design[6]. In particular it was shown that fields of different type could be superimposed linearly so that different correction functions can be applied simultaneously. Following a number of design alterations to improve the magnet performance a contract was placed with Danfysik A/S, Denmark, for the construction of 18 pro-

duction magnets. After an extensive series of tests at Daresbury 16 of these were then installed in the storage ring. Full details of this phase of the project may be found in ref.[7]. The magnets are now fully commissioned and are playing an important role in commissioning the new facility.

GENERAL DESCRIPTION

Figure 1 shows a simplified cross section of the multipole magnet which is a symmetric 12 pole structure with a thin annular yoke. The magnet is powered by two separate sets of coils. The larger water-cooled coils positioned on six of the poles are connected in such a way as to produce a powerful sextupole field. The 12 yoke coils on the other hand carry a much lower current and are cooled by natural convection. These are designed to be powered individually under computer control. The field levels in the steel are sufficiently small even in the presence of the main sextupole field so that different field types can be superimposed linearly.
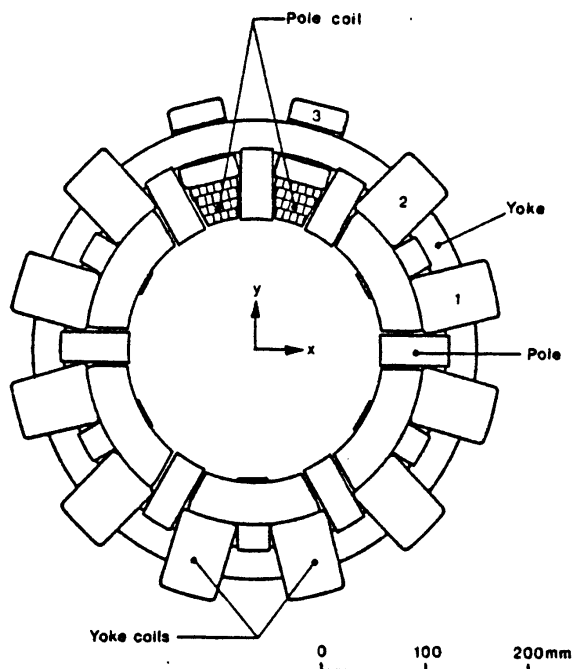

Fig.1 Cross section of the multipole magnet.

The type of field generated by the yoke coils depends on the distribution of current in them. In Table 1 the currents used in producing normal fields ranging from dipole to decapole and also skew-quadrupole are shown, normalised to a maximum of 1.0. Only the three

Table 1

Required Field	Current in Multipole Windings			Reflection in x axis	Reflection in y axis	Other fields present from symmetry considerations
	1	2	3			
Dipole	1.0	0.732	0.268	+	−	3,5,7 ...
Quadrupole	1.0	0.0	−1.0	+	+	6,10,14 ...
Sextupole	1.0	−1.0	−1.0	+	+	9,15,21 ...
Octupole	0.5	−1.0	0.5	+	−	8,12,16 ...
Decapole	0.288	−0.762	1.0	+	−	3,5,7 ...
Skew-quadrupole	0.333	1.0	0.33	−	−	6,10,14 ...